Forefronts of Research Educational Modules

Discussion Notes

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Aims, Goals, Objectives

Project FOREM aims to engage the curiosity of students and inspire their imagination. This is a natural way to learning, especially when it comes to science. The high school science curriculum typically deals with classic subjects. In physics, for example, it covers motion, kinematics, Newton's classical laws of motion—subjects that have been around for centuries. While this provides a foundation for more advanced topics, the focus on "old physics" is prone to creating an abstract environment that students may find hard to engage in. FOREM aims to provide a solution to this challenge to motivate better learning and deeper understanding.

To this end, FOREM's goal is to bring to high school classrooms recent topics of research or modern scientific points of view. The project's immediate objective is to develop short educational modules that can be adapted by high school teachers into their classes without a major overhaul of curriculum or course plans. Each module will be based on a framework that emphasizes the actual practice of science and inquiry. The final product will lay out a guided plan of inquiry through interactive activities, labs, computer simulations, and use of new classroom technologies.

In the following sections, I list some questions to be considered by workshop participants for further discussion. These questions are only to provide a guide for our discussion and not a rigid agenda. The actual discussion will be organic and may end up taking a different course. However, the topic of these notes will be used as a general guide for the workshop.

Best practices for high school science classes

Since FOREM targets high school students, it is important to design the modules based on best practices specifically for this age group. High schoolers have had previous experience with science lessons and are ready to tackle more advanced topics in more depth. This also provides a great opportunity to engage them in more recent progress. They might be already hearing about such things as wireless power transmission, new automative technologies, gravitational waves, space travel, genetic engineering, hydrophobic material, quantum computers, superconductivity, etc. A short module addressing some of these topics is therefore a great way to engage their interest in the broader scientific enterprise.

While a full lesson on any of these subjects is beyond the scope of high school physics, the main insights and perspectives enabling their modern understanding is not. For example, a detailed understanding of superconductivity requires knowledge of such advanced topics as quantum mechanics, crystal vibrations, electronic interactions and coherence. However, underlying the phenomena is the special way that electrons in a superconductor organize their motion. This well-organized motion follows some simple *symmetry* principles. Indeed, symmetry is a core concept in much of modern physics. Even in classical physics, it was understood by Newton's scientific descendants that symmetry underlies the conservation laws of energy and momentum. Therefore, a discussion of superconductivity at this level need not focus on technical details, but on how a knowledge of symmetry deepens our understanding of the laws of nature. The connection to superconductivity can then follow.

1) What type of preconceptions do high school students usually have?
2) What are some of their typical misconceptions?
3) How do you proceed with addressing these pre- and misconceptions?
4) What is the most difficult aspect of a high school science lesson planning?
5) In your experience, what are the best practices for planning a high school science class?

Best practices for student engagement

Student engagement is the main aim of project FOREM.

1) How do you plan the course to engage the students?
2) What specific methods do you use to increase student participation?
3) What methods have you used that were not effective? Why?
4) In your experience, what are the most effective ways to engage students?
5) Is there a way that you usually start each class? Do you follow a pattern during the class? How do you end each class?

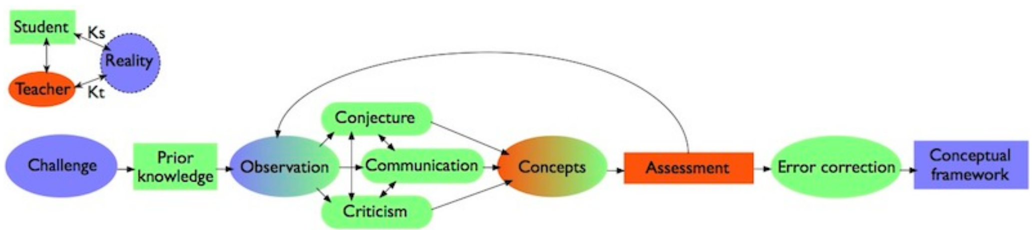
Best practices for learning through inquiry

In traditional classrooms, active inquiry by students does not play a big role. Recently, inquiry-based teaching has seen increased interest both in education research and practice. Project FOREM views inquiry not just as a method of teaching, but as an essential part of learning and scientific discovery. The modules developed for FOREM are meant to rely mainly on inquiry, not only as a method of teaching, but also as the actual practice of science. Of course, as an educational unit, this is inquiry with the purpose of learning — it is a guided inquiry. Thus, a well-planed structure is needed and the teacher must guide the process to achieve this purpose.

1) What is our experience with hands-on, inquiry-based, or project-based teaching?
2) How do you use these methods in your class?
3) What challenges have you encountered with such methods of teaching? How can they be avoided?
4) What benefits do you see with such methods? How do you achieve them?
5) In your experience, what are some of the best practices of inquiry-based teaching?

Module framework: components, activities, plan of inquiry

As outline before, the modules follow a framework of guided inquiry. This process incorporates a central challenge, and involves observations, communications, evaluations, and formative assessment to construct the intended conceptual framework. A diagram showing the proposed framework for a module is shown below.



Thinking of your own class, consider the following:

1) How can this flow be implemented in practice?
2) What tool scan be used to help with this structure? (Blackboard, iPads, etc.)
3) When and how should demos be used? What about computer simulations?
4) How can group discussions be used? How can they be guided?
5) Can discussions be conducted with the whole class?
6) How can assessment be implemented as part of the process?
7) How can the teacher guide the process?
8) How do you implement these elements in your teaching?
9) What challenges do you see with this method?

The first two modules

This year, the goal of the project is to develop 1-2 modules for use in classrooms starting Spring 2017. Here are some ideas for the topic of these first two modules. What are your suggestions? What subjects do you think would be easier for an inquiry-based module?

1) Symmetry: how simple forms rule our world
2) Superconductivity: the race to the coldest temperatures and back
3) Waves: from sound to gravitations waves
4) GPS: asking Einstein to locate you
5) Quantum information: parallel possibilities
6) Wireless power transmission: the battle between Edison and Tesla
7) Space travel: what it takes to step out of our planet
8) ....